

*Title : will be set by the publisher*  
*Editors : will be set by the publisher*  
*EAS Publications Series, Vol. ?, 2015*

## H<sub>2</sub> DISTRIBUTION DURING 2-PHASE MOLECULAR CLOUD FORMATION

V. Valdivia<sup>1,2</sup>, P. Hennebelle<sup>3</sup>, M. Gerin<sup>1</sup> and P. Lesaffre<sup>1</sup>

**Abstract.** We performed high-resolution, 3D MHD simulations and we compared to observations of translucent molecular clouds. We show that the observed populations of rotational levels of H<sub>2</sub> can arise as a consequence of the multi-phase structure of the ISM.

### 1 Introduction

Because the H<sub>2</sub> formation time is long (some  $10^9/n$  yrs, where  $n$  is the density in  $\text{cm}^{-3}$ ), and can exceed the crossing time of molecular clouds ( $t_{\text{cross}} = 10^6 (\frac{r}{1 \text{ pc}})^{0.5}$  yrs), it is important to consider the impact of dynamical effects on the evolution of the H<sub>2</sub> fraction. To understand the H<sub>2</sub> molecule formation process under the dynamical influence of a highly inhomogeneous structure, such as that of molecular clouds, where warm and cold phases are interwoven, we performed high-resolution MHD simulations of realistic molecular clouds formed through colliding streams of warm atomic gas. For this study we used the RAMSES code (Teyssier 2002), where we included the formation and destruction processes for H<sub>2</sub>, as well as the thermal feedback (see Valdivia *et al.* 2015). The effects of dust shielding for the UV radiation, and the self-shielding due to H<sub>2</sub> molecules were included by using our tree-based method, detailed in Valdivia & Hennebelle (2014).

### 2 Results

H<sub>2</sub> is mainly formed in dense regions (Fig. 1 *left*), and it is formed faster than the usual estimates based on the mean density of the cloud (Fig. 1 *center*), about

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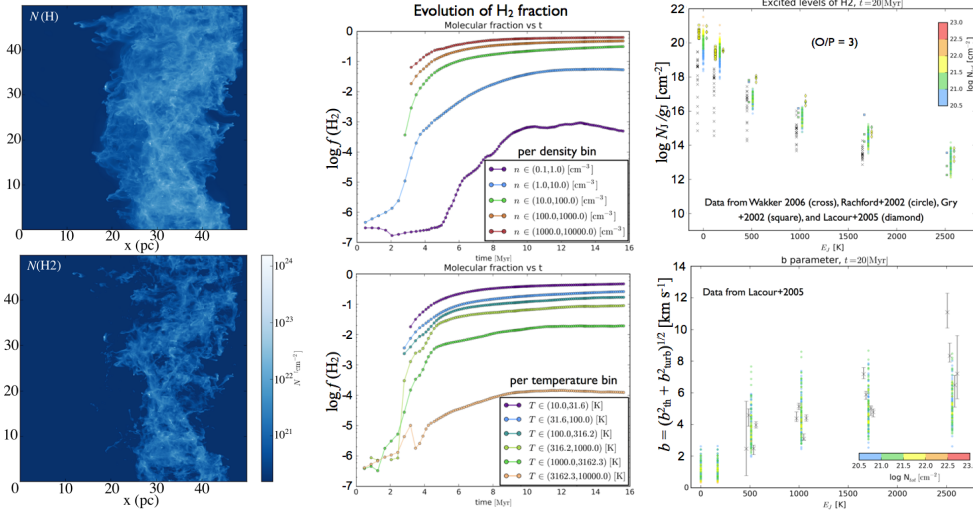
*Aknowledgements:* CNRS-CONICYT; COSMIS project; PCMI; MesoPSL

<sup>1</sup> LRA/LERMA, Observatoire de Paris, École Normale Supérieure (UMR 8112 CNRS), 24 rue Lhomond, 75231 Paris Cedex 05, France; e-mail: [valeska.valdivia@obspm.fr](mailto:valeska.valdivia@obspm.fr)

<sup>2</sup> Sorbonne Universités, UPMC Univ Paris06, IFD, 4 place Jussieu, 75252 Paris Cedex 05, France

<sup>3</sup> Laboratoire AIM, Paris-Saclay, CEA/IRFU/SAP - CNRS - Université Paris Diderot, 91191 Gif-sur-Yvette Cedex, France

4 Myr instead of 20 Myr for  $\bar{n} \sim 50 \text{ cm}^{-3}$ . We interpret this as the result of the combined effect of the local density enhancement, that drives a faster  $\text{H}_2$  formation (see also Glover & MacLow 2007), and the shielding provided by the global structure, that ensures the survival of molecular gas. Additionally, the mixing between different phases induce the presence of  $\text{H}_2$  molecules in the warm phase, explaining the observed warm  $\text{H}_2$  in the diffuse ISM. We have calculated the  $\text{H}_2$  populations in the first levels at thermal equilibrium, as well as the Doppler broadening parameter  $b$  for each population (Fig. 1 *right*). Excitation diagrams and  $b$  parameters are in good agreement with the values observed by Copernicus and *FUSE* (Lacour 2005, Gry *et al.* 2002, Rachford *et al.* 2002, Wakker 2006). Altogether, these results suggest that excited populations might be the consequence of local temperature and density within molecular clouds, highlighting the multi-phase nature of molecular clouds.



**Fig. 1.** *Left:* Total H, and  $\text{H}_2$  column densities. *Center:*  $\text{H}_2$  fraction evolution per density bin and per temperature bin. *Right:*  $\text{H}_2$  population distribution, and  $b$  parameter.

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